Severe weather events in Moldavia region, on June 23, 2019

Diana-Corina BOSTAN[1], Adrian TIMOFTE[2]* and Sorin BOSTAN[3]
[1]National Meteorological Administration, Bacău Regional Forecast Center, 3 Timpului Street, 600234, Bacău, Romania
[2]"Vasile Alecsandri" National College, 37 Vasile Alecsandri Street, 600011, Bacău, Romania

*Correspondence to: Adrian TIMOFTE. E-mail: timofte.adrian@gmail.com.

Vol. 31/2021, 44-62

GEOREVIEW

Published:

1 November 2021

ABSTRACT: The forecast of torrential rainfall is quite laborious and sometimes difficult. The difficulty lies in estimating the quantitative threshold and the spatial distribution of rainfall. Such a study is necessary because it has been found that in the last 30-40 years, the severity of convective phenomena has increased. Through such studies, it is desired to improve the short and very short-term weather forecasts, so that the population and the authorities can limit, as much as possible, the damage in the field. In operational meteorology we constantly work with the concepts of isobars, isohypses, isohyets. In our study, we used another meteorological parameter, less used in the operative routine (in addition to those commonly used) - the equipotential temperature, respectively the map of vertical section with the distribution of isentropes, to analyze severe meteorological phenomena, which took place in the Moldavia region. Forecasts are easy when forecast models are heading in the same direction. But, things get complicated when the atmospheric instability is much more severe than initially anticipated and the phenomena are in full development. The solution to this is found in the fact that the forecasting activity also has a special segment - very short-term forecasts, namely nowcasting forecast (which is based on the interpretation of radar imaging). In this paper, such an example is presented. Due to minor changes in the air circulation in the lower troposphere, the convective phenomena were much more severe than those anticipated by the forecast models. On June 23, 2019, 23 immediate warning messages were issued until midnight, regarding torrential rains, storms and hail. From those issued, 21 were orange code warnings and 2 were red code warnings. In this way, the authorities intervened in due time, so that the losses in the field were minimized as much as possible.

KEY WORDS: atmospheric instability, storms, torrential rains, flood.

1. Introduction

In their paper, Maier et al. (2011) specify the importance of using the WSR-98 D Doppler radar (located at Bobohalma) in the very short-term forecasting activity. Analyzing the years 2004-2008, they found a new method to establish a relationship between radar estimates related to precipitation and precipitation recorded in the field. In our work, we used radar imaging from the WSR 98-D Doppler radar, in S band, located in Bârnova, in Iaşi county.

To highlight convective storms, we used various radar products such as One Hour Precipitation, Three Hour Precipitation, Base-Reflectivity (0.5 elevation), Composite Reflectivity (1 km resolution), Base-Velocity (0.5 and 1.5 elevation).

Overall, June 2019 was characterized by maximum air temperatures that did not exceed the value of 30 degrees Celsius. The heatwave threshold was reached only in the extreme south of Moldavia region, in 3 days of the last decade of the month (on the 22nd, 23rd and 27th). Coupled with the presence of a high percentage of relative humidity determined the maintenance of a severe thermal discomfort, especially after June 12. June 2019 was a rainy month, and atmospheric instability was increased in most of Moldavia region. In 21 of the days of the month it rained torrentially and the recorded water quantities exceeded by over 100 % the climatological values of the specific precipitations of the month, especially in the counties located in the central part of the region (www.meteoromania.ro).

On the evening of June 23, it rained heavily in the counties of northern and central Moldavia region. The showers were accompanied by frequent electric discharges and short-term wind intensifications that took the form of squall in Bacău, Vaslui and Botoşani counties. The water resulting from the fallen precipitations and from the leaks from the slopes entered the households of the people from several localities and affected several roads in Bacău and Neamţ counties. This paper evaluates the factors that generated this special situation on the evening of June 23 and the night of June 23/24, and with the help of Doppler radar WSR-98 D, the event was detailed up to the scale of storm.

Overall, the short-term and very short-term forecasting activity has two important objectives; first- to improve meteorological forecasts (using satellite and radar imaging, maps with the distribution of electric discharges, aerological radiosondes, Mesoscale Numerical Weather Prediction, etc.) and second- minimal damage and material loss and most importantly zero human losses, by warnings issued with enough time for necessary measures to be implemented by local authorities.

2. Study area

Moldavia region is characterized by a harmonious combination of all forms of relief. There are three major landforms, namely: the high- of the mountains, the medium; which corresponds to the hills and plateaus and the low, which includes the plains. The maximum amounts of precipitation in 24 hours have an important role in generating the processes of erosion and landslides, causing frequent floods. The duration and intensity of the rains highlight a great temporal and spatial variability, depending on the direction of movement of the air masses and the position of the Carpathian arc. Thus, the rains with the longest duration (over 190 minutes) occur in the west and north of the country, and those with the shortest duration (under 150 minutes) occur in regions with föhnal manifestations or continental air advections. Torrential rains vary territorially depending on altitude, landform, Carpathian position, local conditions and weather, sometimes accompanied by hail (Tanislav, 2010). In Moldavia region, the average quantities in June increase from south to north, from 65 ... 70 l / sqm in the Siretului Inferior Plain (Galați- 67.8 l / sqm), to 75 ... 85 l / sqm in the Bârlad Plateau (Vaslui- 81.6 l / sqm) and at over 90 l / sqm in the Suceava Plateau (Suceava- 97.9 l / sqm). The multiannual average precipitation of

June increases on the eastern side of the Moldavia region Subcarpathians exceeding 95 ... 100 l / sqm (Piatra Neamț- 95.7 l / sqm) (Clima României, 2008).

The territories least exposed to the risk of summer rains are those in western and central Romania, with oceanic influences that determine the moderate nature of the climate. Most of the country's territory (including the Moldavian Plateau) is characterized by a medium vulnerability. The most exposed to the risk of summer rains are the territories in the central-southern part of Romania, as a result of the continental character of the climate, the influence of the urban topoclimate, the interference of the eastern and western circulations and, respectively, the retrograde Mediterranean cyclones (Georgescu et al., 2015).

In Fig. 1, the region of Moldavia is represented, with its 8 counties. Through the aerological radiosonde data taken from the reanalysis of the data above the central part of Moldavia, the wind speed and direction were determined at several reference levels (1000, 925, 850, 700, 500 and 300 hPa), with the help of data from Air Resources Laboratory (https://ready.arl.noaa.gov/index.php).

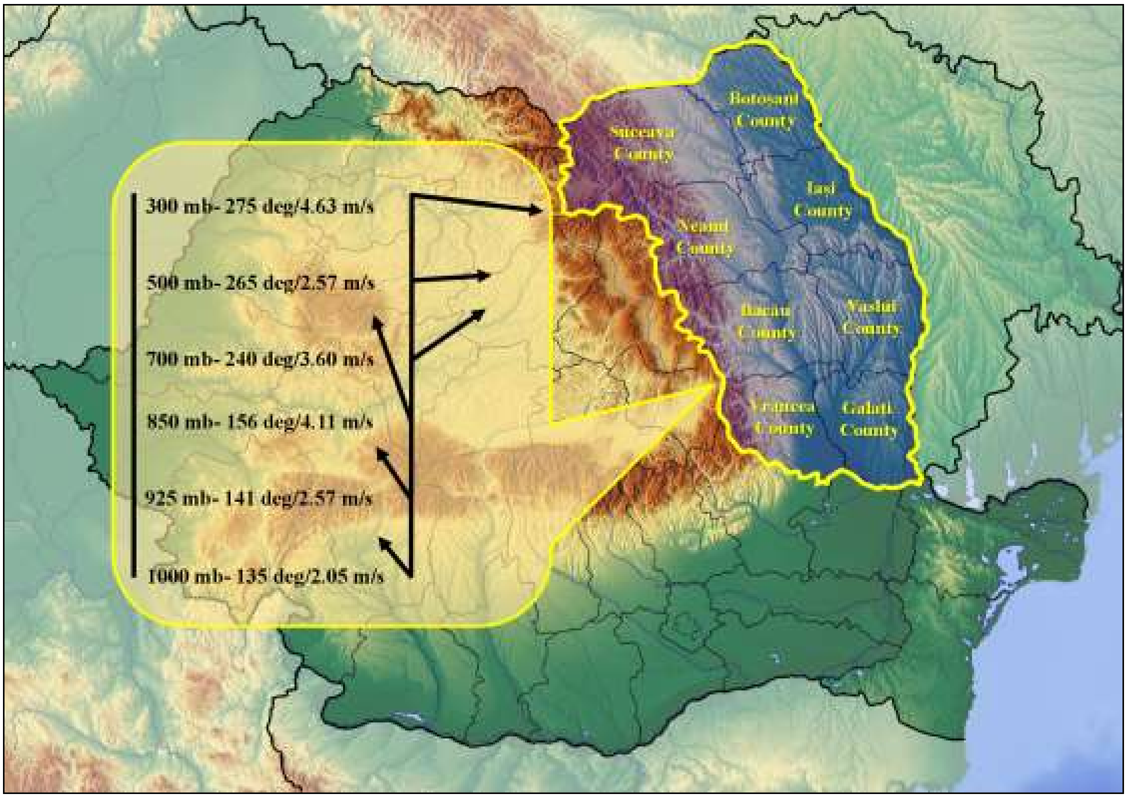

Figure 1 Mesosynoptic context, from June 23, 2019, 12 UTC (Air Resources Laboratory), black arrows, indicate the wind speed and direction at the levels of 1000, 925, 850, 700, 500 and 300 hPa (https://maps-for-free.com/, https://ready.arl.noaa.gov/index.php).

The Regional Forecast Center in Bacău makes long and short term forecasts and issues severe weather warnings for the 8 counties in Moldova - in the western half, for Suceava, Neamţ, Bacău and Vrancea counties, and in the eastern half for Botoşani, Iaşi, Vaslui and Galaţi counties.

3. Methods

In the present paper we operated with some of the models used to make forecasts on a daily basis. Thus, we used data from ECMWF, ARPEGE (https://www.ecmwf.int/, www.meteoromania.ro) and GFS (www.wetter3.de) for synoptic scale analysis, and for mesoscale analysis the ALARO model (www.meteoromania.ro) and data from EUMeTrain (http://www.eumetrain.org/). The instability indices were extracted from the ALARO, ESTOFEX (https://www.estofex.org/) and GFS models. Satellite images were obtained from the EUMeTrain platform and for analysis, we used the Enhanced IR 10.8 channel and an RGB convection product (R WV6.2-WV7.3, G IR3.9-IR10.8, B NIR1.6-VISO .6). In our study we used data from the German Meteorological Service (https://www.metoffice.gov.uk/), internal materials from the National Meteorological Administration and data with the distribution of electrical discharges (www.blitzortung.org).

Ground and altitude maps (850 hPa, 700 hPa, 500 hPa and 300 hPa) of the ECMWF, ARPEGE, ALARO and GFS Numerical Weather Prediction (NWP), as well as observational data from meteorological stations and pluviometric stations were used. The mesoscale structures responsible for severe weather episodes were analyzed and interpreted using WSR-98D Doppler radar images.

3.1. Case analysis

3.1.1. Synoptic context

In the last decade of June, the tropical air mass was present in the southern half of the continent. Starting with June 21, the ridge of Maximum Baric Azoric advances to the northwest of the continent and penetrates to the north of our country. Active nuclei detached from the Icelandic Depression and driven to Western Europe on June 22, isolate the high pressure core to the central-northern part of the continent so that on June 23, at 06 UTC, an anticyclonic core with a value of 1025 hPa was located in northern Poland.

Romania was located at the contact area between this anticyclonic field and the vast depression area that occupies the rest of the continent.

To characterize the synoptic situation, the following maps were analyzed - the synoptic map from the ARPEGE model (base time from June 23, 2019, h18 UTC) where the sea level pressure field is represented by isobars and the thermal field at 850 hPa, represented by isotherm (Figure 2); synoptic map from the UK National Meteorological Service, Met Office, showing the sea-level pressure field by means of isobars and related atmospheric fronts (Figure 3).

The contour of the borders of our country (Romania) was added by the authors, in Figure 3, to facilitate the synoptic analysis and to easily identify the territory of the country.

In the middle troposphere, at 500 hPa, a long-wave trough, in which several nuclei stand out, gradually approaches the west of the continent. On June 22, at 00 UTC, a core of geopotential is individualized on France, which is evolving rapidly to the east. On June 23, at 18 UTC, it is positioned in the west of the country and is found on the atmospheric column up to 300 hPa (see Fig. 4).

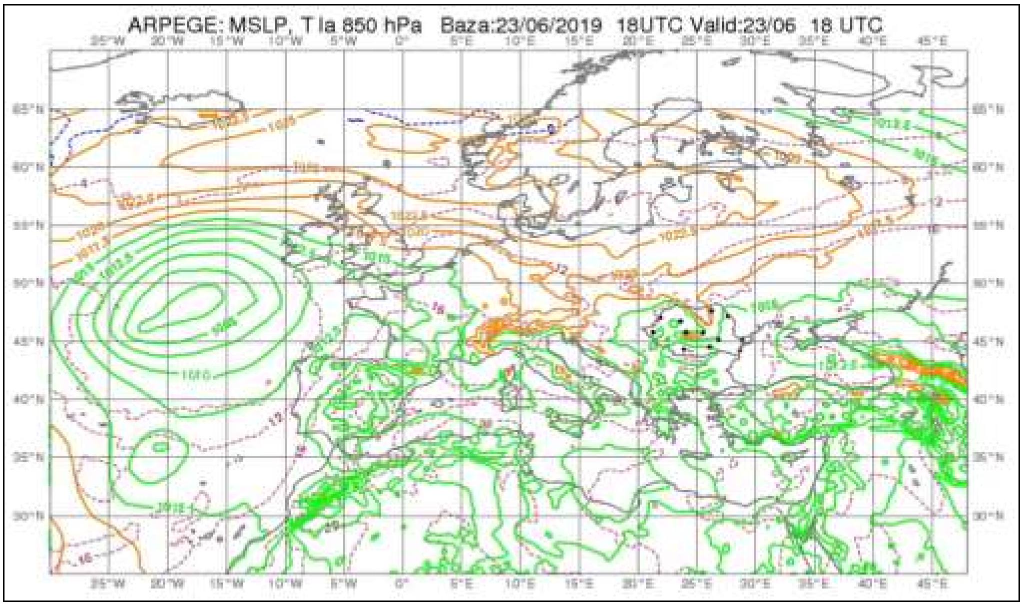

Figure 2 The synoptic context, from June 23, 2019, at 18 UTC. Model ARPEGE initialization at h18 UTC (continuous lines- representation of the pressure field at sea level; pressure values are expressed in mb, dotted lines- representation of the air thermal field at the level of 850 hPa; temperature values are expressed in Celsius degrees).

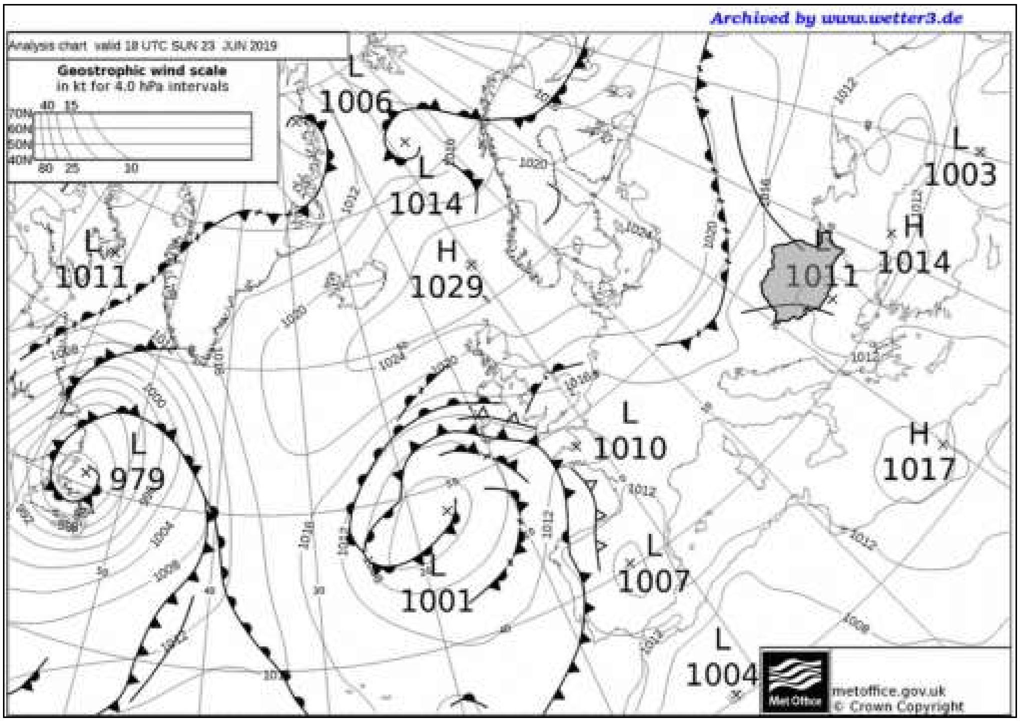

Figure 3 The synoptic context, from June 23, 2019, at 18 UTC. Synoptic map from Met Office; pressure field distribution at sea level; pressure values are expressed in mb (https://www.ecmwf.int/, http://www1.wetter3.de/).

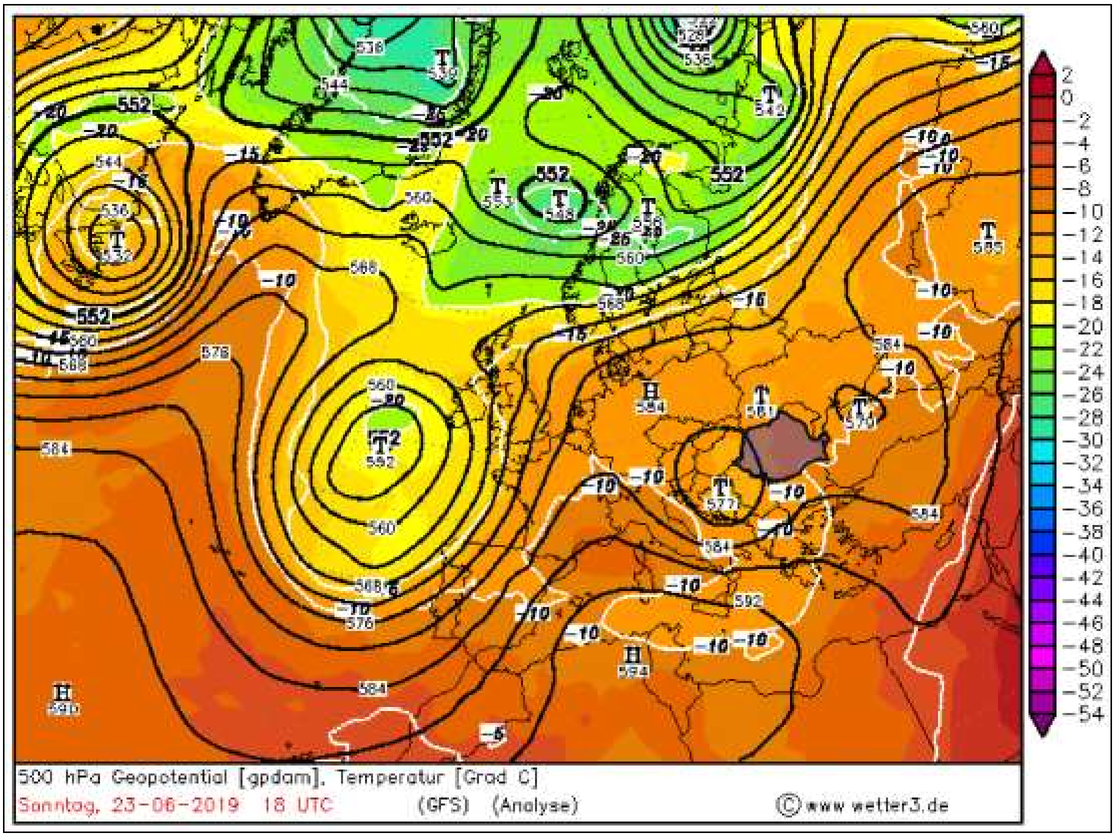

Figure 4 The synoptic context, from June 23, 2019, at 18 UTC, at the level of 500 hPa (continuous black lines - representation of the geopotential field; values are expressed in damgp, continuous white lines - representation of the thermal field at 500 hPa level; the values are expressed in Celsius degrees) (http://www1.wetter3.de/).

3.1.2. Mesosynoptic context

For the analysis of the instability indices at the level of our region, we used data extracted from ESTOFEX, GFS and ALARO.

Romania contributed to the development and validation of a new version of the ALADIN model, called ALARO. This model was designed to be integrated at finer resolutions (around 5 km), containing more complex physical parameters.

In the National Meteorological Administration, this model has been implemented since 2010, in operational regime, four times a day (with an anticipation of up to 78 hours), on a field that covers the area of Romania.

To view the results, a new procedure for post-processing output files in grib format was implemented, a new graphics package based on Magics was developed and a new web page was created (www.meteoromania.ro).

One of the "products" that ALARO offers is the representation of the distribution of convective precipitation near and above the Romanian territory. For the analysis, maps with convective precipitation distribution were used, from the ALARO model, initialized at 12 UTC. Thus, the maps from June 23, 2019, h 18 UTC and from June 24, 2019 h00 UTC were interpreted and analyzed (Fig. 5 and Fig. 6).

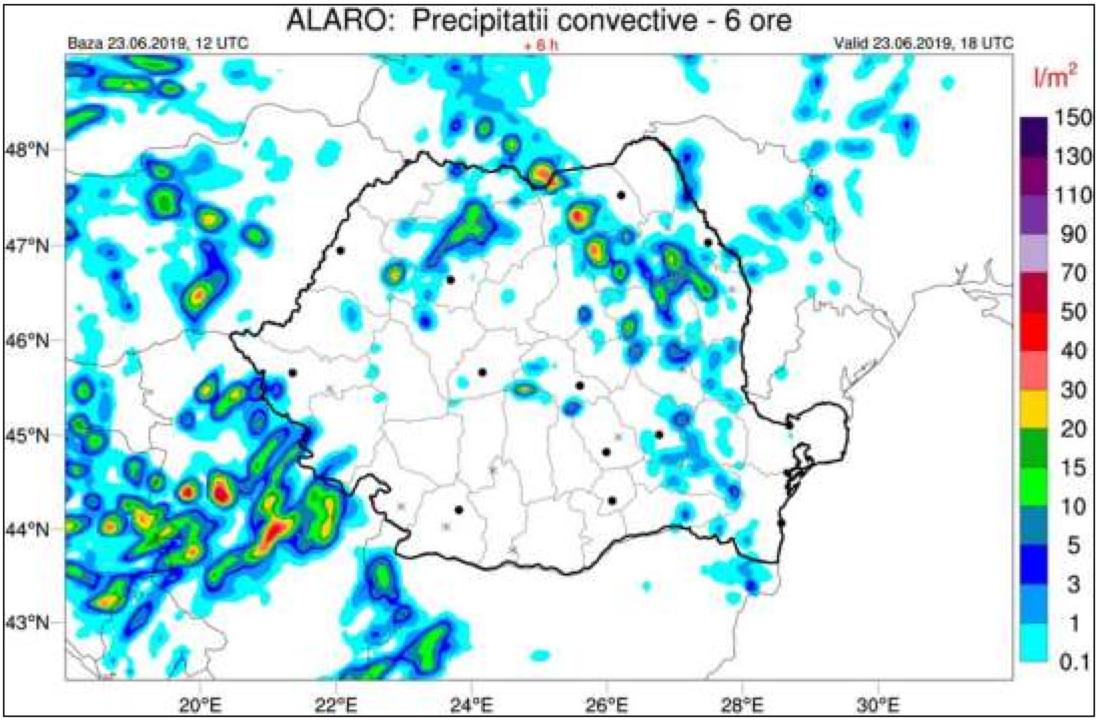

Figure 5 ALARO model - convective precipitation - 6 hours, base from the June 23, 2019 at 12 UTC, precipitation at h18 UTC (www.meteoromania.ro).

In the lower troposphere (at the level of 850 hPa), there is an influx of hot and humid air from the western Black Sea basin, while on the tropospheric column, the air circulation had an anticyclonic behavior, without reaching shear values, which could have indicated severe storms.

NWP from the morning of June 23, at 06 UTC, indicated relatively low signals of the events that could have taken place on this day, with a higher probability on the northern group of the Carpathian Mountains area. The precipitation product of the ALARO model, running at 12 UTC, although it captured more intense nuclei with values of 30 ... 40 l / sqm or even 50 l / sqm in the 6-hour estimation, their position and their spatial distribution was much out of step compared with the real situation (see Fig. 5 and Fig. 6) (www.meteoromania.ro).

The lift index (LI) is a stability index for determining the occurrence of characteristic phenomena of severe weather (bad weather); it is defined by a relationship involving the temperature of the dry thermometer at 500 hPa and the temperature of a particle lifted adiabatically at 500 hPa. The stability conditions are indicated by LI values> 3, and the very unstable ones by LI values <-2 (Runcanu, 2014).

ETOFEX- MLCAPE values between 1200-1600 J / Kg in the north and center of Moldavia region, with the highest values (up to 2000 J / Kg) in the north and mountain area at 15 UTC. The signal indicated that by evening, several storms with a possible severe character (there were no predicted shears), would spread especially over northern Moldavia region and in the mountains. Normally, shears above 15 m / s can usually lead to storms that are fairly well organized and capable of producing hail of about 2 cm. On this day, shearing was not reported for our region (at 18 UTC, shearing less than 10 m / s in the Republic of Moldova, on the border with Romania) (http://www.estofex.org/).

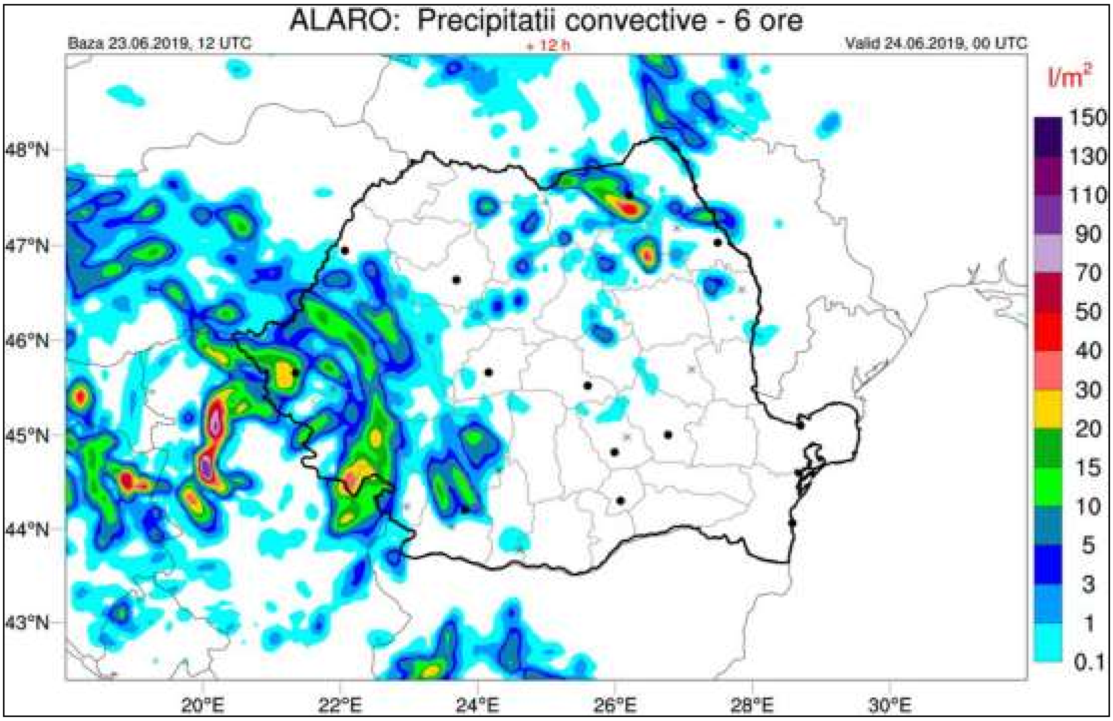

Figure 6 ALARO model - convective precipitation - 6 hours, base from the June 23, 2019 at 12 UTC, above precipitation at h00 UTC (www.meteoromania.ro).

GFS-MLCAPE values between 800-1200 J / Kg in the area of Moldavia region, with a maximum located in the northeast of Moldavia region. Lifted Index had values between 0 and -2 (slightly unstable atmosphere, possible storms, with ascent mechanism), and the maximum values were for 12 UTC (http://www1.wetter3.de/).

According to NOAA- Storm Prediction Center, "MLCAPE is a measure of instability in the troposphere. This value represents the mean potential energy conditions available to parcels of air located in the lowest 100-mb when lifted to the level of free convection (LFC). No parcel entrainment is considered." (https://www.spc.noaa.gov/) MLCAPE is an acronym that comes from Mixed Layer Convective Available Potential Energy.

The K index (George's index), is a stability index defined by a relationship involving dry thermometer temperatures at 850, 700 and 500 hPa, respectively, and dew point temperatures at 850 and 700 hPa (Runcanu, 2014). How is it interpreted? Values between 30 and 35 indicate scattered storms, and values between 35 and 40 indicate numerous storms (www.meteoromania.ro).

Fig. 7 and Fig. 8 represent the K-index distribution, above and around Romania. The ALARO model offers the possibility to view this product, and for the analysis of our case, we used the model with initialization at 12 UTC (from June 23, 2019).

ALARO-K-Index had values between 30 and 35 (scattered storms) in most of Moldovia region, and the maximum values were forecast especially for 12 UTC, for the mountainous and submontane area of Moldovia region, with values between 35 and 40 (numerous storms) (www.meteoromania.ro).

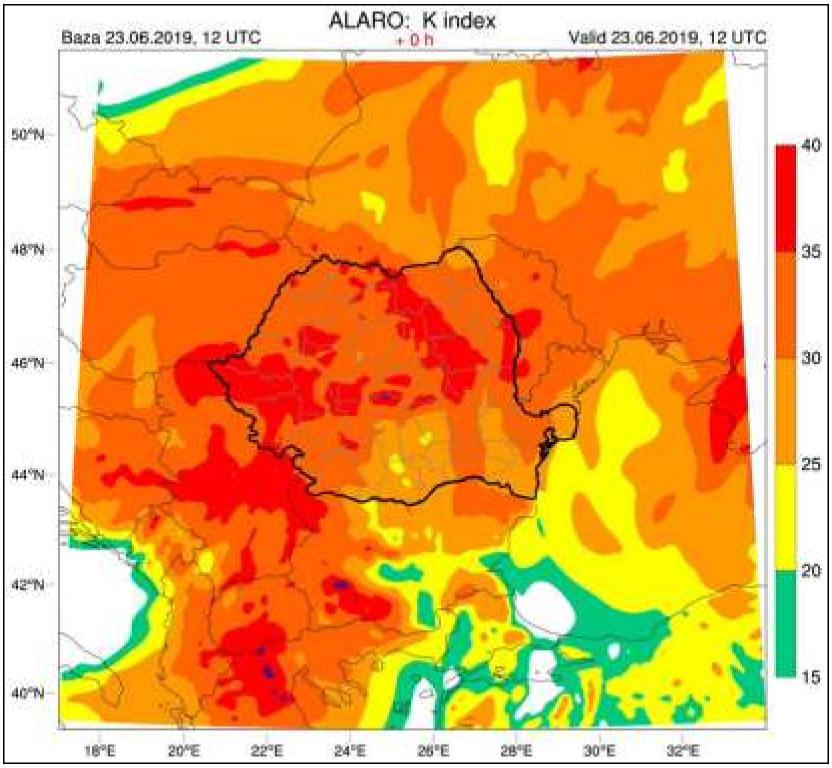

Figure 7 Model ALARO-K Index, base from the June 23, 2019, at 12 UTC (www.meteoromania.ro).

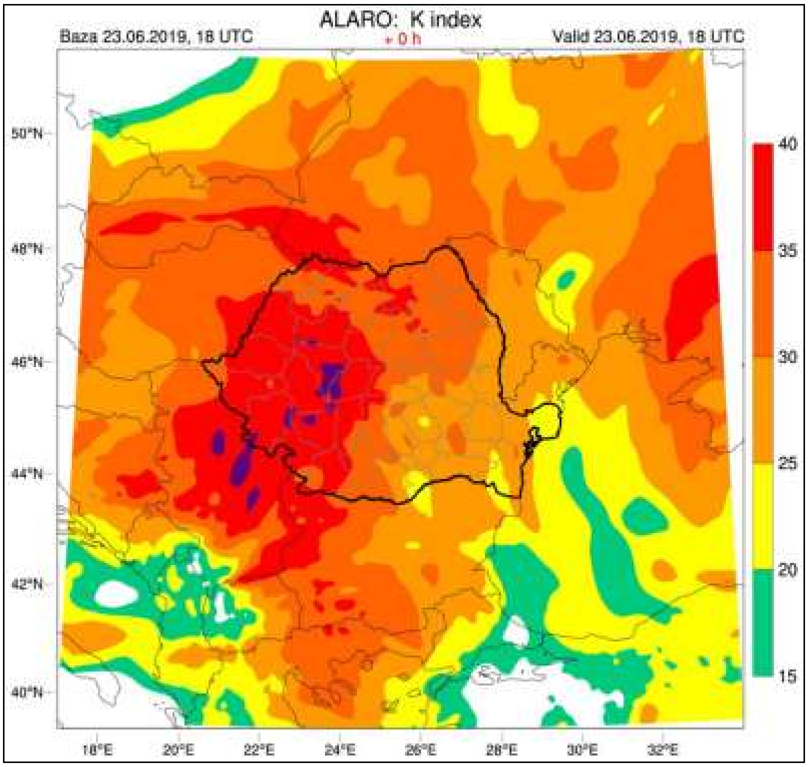

Figure 8 Model ALARO-K Index, base from the June 23, 2019, at 18 UTC (www.meteoromania.ro).

On June 23, in Moldavia region, the meteorological phenomena began to spread from noon onwards, so that by midnight, 23 immediate warning messages were issued until midnight, regarding torrential rains, storms and hail. From those issued, 21 were orange code warnings and 2 were red code warnings. The first red code, issued immediately after 7.30 pm, targeted Bacău and Neamț counties, areas where the water quantities reached and exceeded 50 l / sqm.

In the activity of issuing nowcasting messages, informational synergy is essential (Bostan D.C. et al., 2018). Thus, the latest runs of the mesoscale forecast models, satellite images, storm distribution, lightning maps and especially radar imaging (updating data every 6 minutes) are followed simultaneously. For example, we used and interpreted satellite imaging provided by the IR 10.1 Enhanced channel to see storm distribution, from the territory of our region (see Fig. 9) Lightning maps were used to determine the severity of the storms (see Fig. 10) (http://www.eumetrain.org/, http://en.blitzortung.org/live_lightning_maps.php https://www.eumetsat.int/).

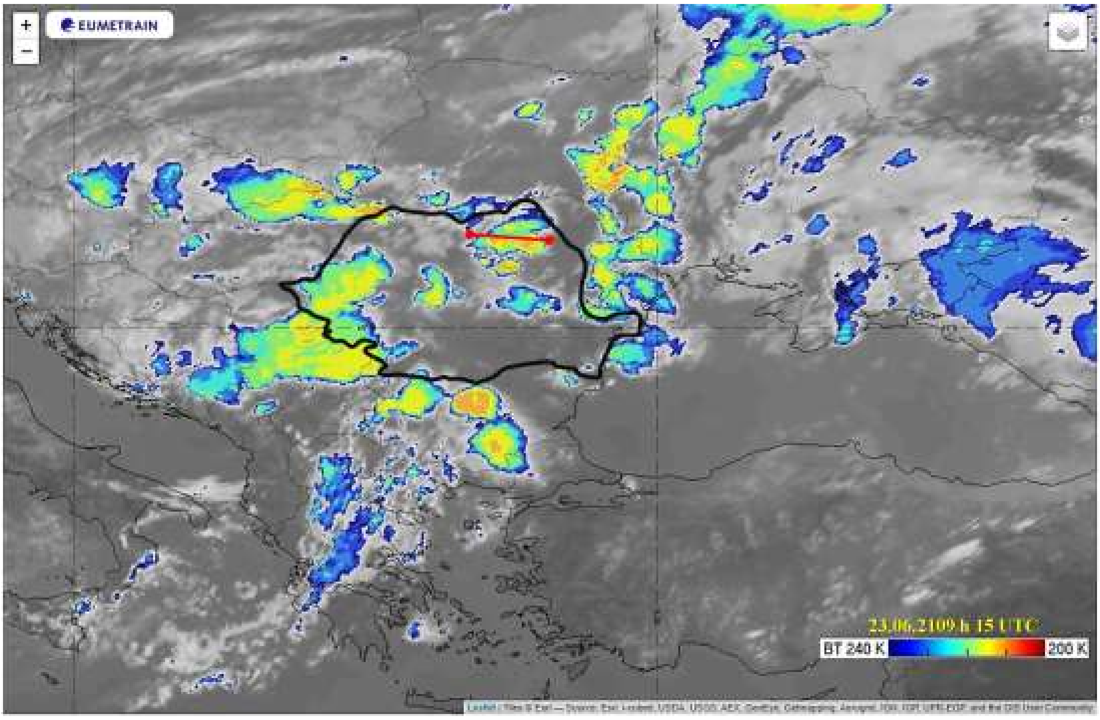

Figure 9 Satellite images - IR 10.1 ENHANCED, from June 23, 2019 – at 15.00 UTC. The red line indicates where the vertical section was made (http://www.eumetrain.org/, https://www.eumetsat.int/).

Sun et al. (2019) affirm that lightning and precipitation are present in thunderstorms quite frequently. There is a relationship between these two diffrent phenomena which has been studied so far for a long period of time. Thus, studies have shown various results- some of them indicate that the first occurence is that of the peak of lightning-flash, followed by the peak of rainfall.

According to others, there can't be established a clear temporal connection between the two phenomena. Another aspect that was taken into discussion was the spatial distribution between lightning and precipitation. The conclusion was that there is an obvious correspondence between the regions with strong lighting activity and those of heavy rainfall.

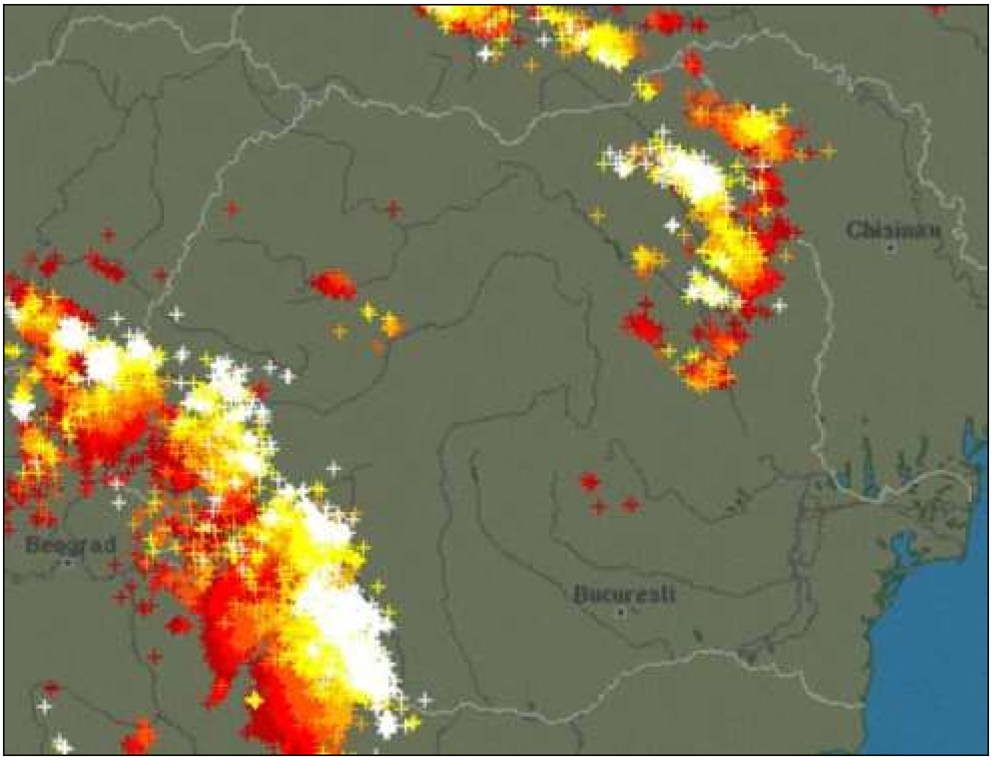

Figure 10 The distribution of electric discharges on the territory of Moldavia region. http://en.blitzortung.org/live_lightning_maps.php).

In Fig. 10, at 15 UTC an intense electrical activity can be observed. This can indicate severe storms with significant rainfall.

"Updrafts and downdrafts in convective systems can form complex and variable airflow fields. The convergence, divergence, cyclonic rotation, and anticyclonic rotation are the four structure types of the airflow field. […] The types and intensities of these four airflow structures [...] usually have a high correlation with the development and evolution of the convective systems and have significant effects on convective weathers. […] Therefore, it is important to recognize these structures of airflow field" (Wang, 2020).

With the help of Doppler radar, the structure of the air flow can be visualized. Thus, the way in which the radial velocities in radar images are distributed and, depending on their structure, can provide crucial information about the development and movement of a storm. For mesoscale systems there are several patterns - pure convergence, pure divergence, cyclonic rotation, anticyclonic rotation, as well as derivatives of the main patterns.

In order to highlight some details about the storms of the evening of June 23, 2019, we selected two radar images from that date, at 14.34 UTC (Base Reflectivity- elevation 0.5 deg) and 15.00 UTC (Base Velocity- elevation 1.5 deg). In the figures below you can view and analyze the basic product of the WSR 98-D meteorological Doppler radar, Base Reflectivity (BR) (in Fig. 11) and Base Velocity (BV) (in Fig. 12).

Radar reflectivity is a measure of the efficiency wherewith a radar target intercepts and returns radio energy; it depends on the size, shape, appearance and dielectric properties of the target surface and includes not only the reflection effects but also those of diffusion and diffraction. It represents the sum of all retro scatter sections per unit volume (Runcanu, 2014).

The radar from Bârnova, in Iași County, is an S-band Doppler radar. This frequency band in the electromagnetic spectrum corresponding to wavelengths between 7.5 and 15 cm, is frequently used in radar meteorology and air traffic control [11]. One Hour Precipitation (OHP) estimates the amount of precipitation that could accumulate in an hour.

The interpretation of the data is done by the forecast meteorologist, because this product is complex. In radar theory, the Z-R relationship represents the relationship between the radar reflectivity (Z) of precipitation and their intensity; this varies depending on the type and nature of precipitation. Established by J.S.Marschall and W.M.Palmer in 1948 to determine the size of precipitation droplets has the form: $Z = 200R^{1,6}$, where $Z(mm^6m^{-3})$ is the reflexivity factor and $R(mm.h^{-1})$ is the precipitation rate, and in generalized form $Z=aR^b$, where a and b are adjustable parameters (Runcanu, 2014).

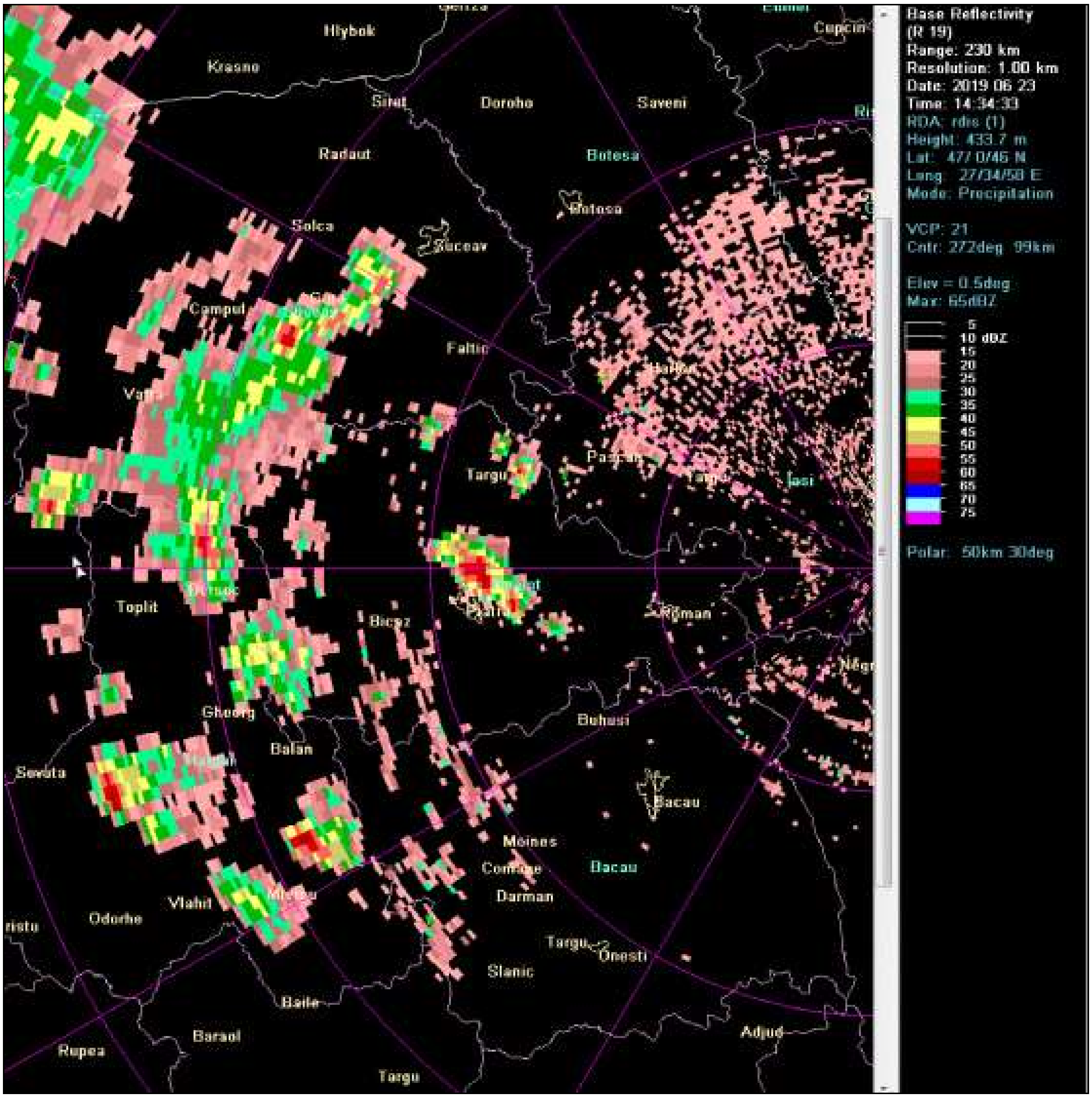

Figure 11 WSR 98-D radar image, Bârnova radar, Iași county - Base Reflectivity (dBZ), elevation 0.5 deg, from 23.06.2019 h 14.34 UTC (www.meteoromania.ro).

Fig. 11 shows the Base Reflectivity product, elevation of 0.5 degrees, with filter applied for reflectivities between 5-10 dBz. If in the southeast of Suceava county we can observe at 14.34 UTC reflectivities with the highest values between 55-60 dBz, and in the central part of Neamt county, we have the highest values between 60 and 65 dBz.

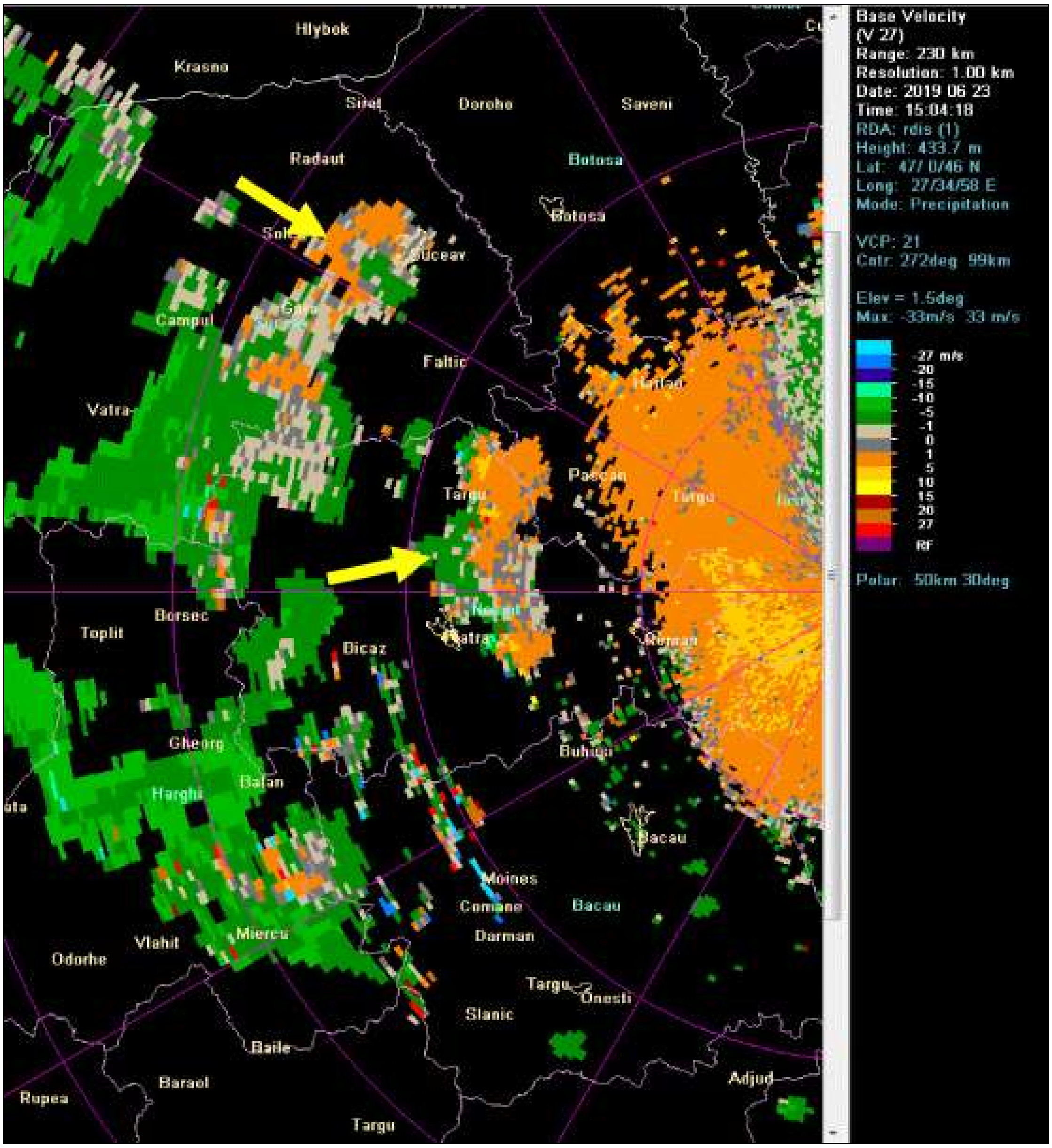

Figure 12 WSR 98-D radar image, Bârnova radar, Iași county – Base Velocity (m/s), elevation 1.5 deg, from 23. 06.2019 h 15.04 UTC, (www.meteoromania.ro).

Fig. 12 shows another base radar product, Base Velocity, but the elevation is 1.5 degrees. According to the explanations in Fig. 8, in the eastern part of Suceava county a divergent movement can be observed, and in the central part of Neamt county a convergent movement is developing. Considering that the elevation is 1.5 degrees, practically at a height of about 3000 m, the convergent movement is located (the storm is developing).

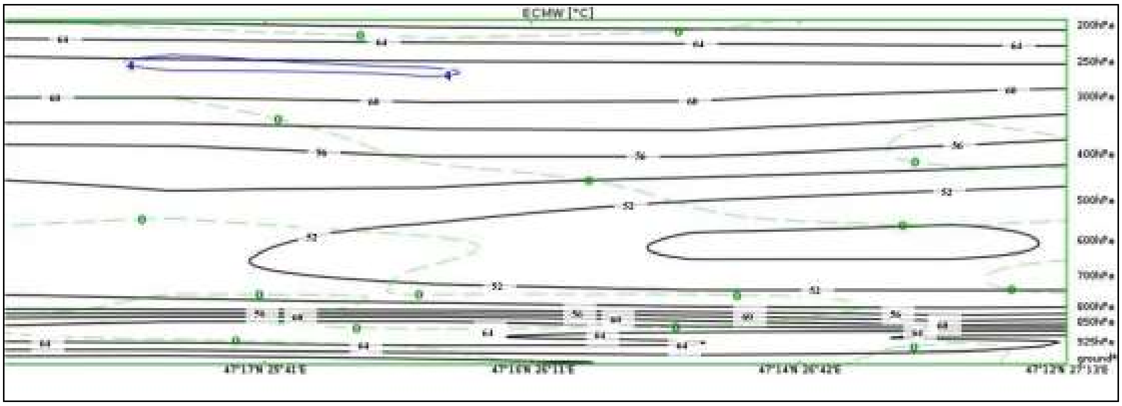

Figure 13 Cross-Section from map. Equivalent Potential Temperature and Convergence/ Divergence for 47˚19’ N 25˚10’E-47˚12’ N 27˚13’E, valid for 23th of June 2019 h 15.00 UTC (http://www.eumetrain.org/).

Fig. 13 is about the vertical section highlighted in Fig. 9 with a red line. In this map are represented the isentropes distributed in a vertical section, respectively convergence and divergence. Normally, the potential temperature increases with altitude. If it decreases with altitude, then we can talk about instability. In practice, equivalent potential temperature is used. Theta-E is a quantity that is conserved during changes to an air parcel's pressure (that is, during vertical motions in the atmosphere), even if water vapor condenses during that pressure change. It is therefore more conserved than the ordinary potential temperature, which remains constant only for unsaturated vertical motions (pressure changes).

In the adjacent figure (Fig. 13), starting from the ground, up to about 850 hPa, the equivalent potential temperature decreases with height (from 64K to 52 K), from the left to the right of the figure (convection can occur). Also, in the lower and upper layers, the relative humidity is high, while in the middle layers, the relative humidity is low.

To the right of the image, at about 600 hPa, closed curved lines can be seen, indicating the presence of a convective region (with greater instability). In the area of coordinates 47 17 '' N 25 41''E a portion with divergence (colored in blue) can be observed, between the level of 300 and 250 hPa.

Practically, on the radar you can see in the Neamt county places where convection is in full development, while in the southwest of Suceava county, the severity of the convective cells has decreased a lot. The vertical section practically confirms the areas of convergence and divergence obtained through the Base Velocity product. In practice, the Base Velocity product is recommended to be used, because it is updated every 6 minutes. On the other hand, for research, the vertical sections complete the information given by satellite and radar imaging. “Isentropes are the isolines of potential or equivalent potential temperature. For synoptic scale motions, in the absence of diabatic processes, isentropic surfaces are material surfaces. […] In the same way that sounding enables us to see the stability of the air column above one point, the cross section of the isentropes gives a quick overview of the stability of the atmposphere over larger area. The distance between the isentropes is a measure of static stability” (http://eumetrain.org/).

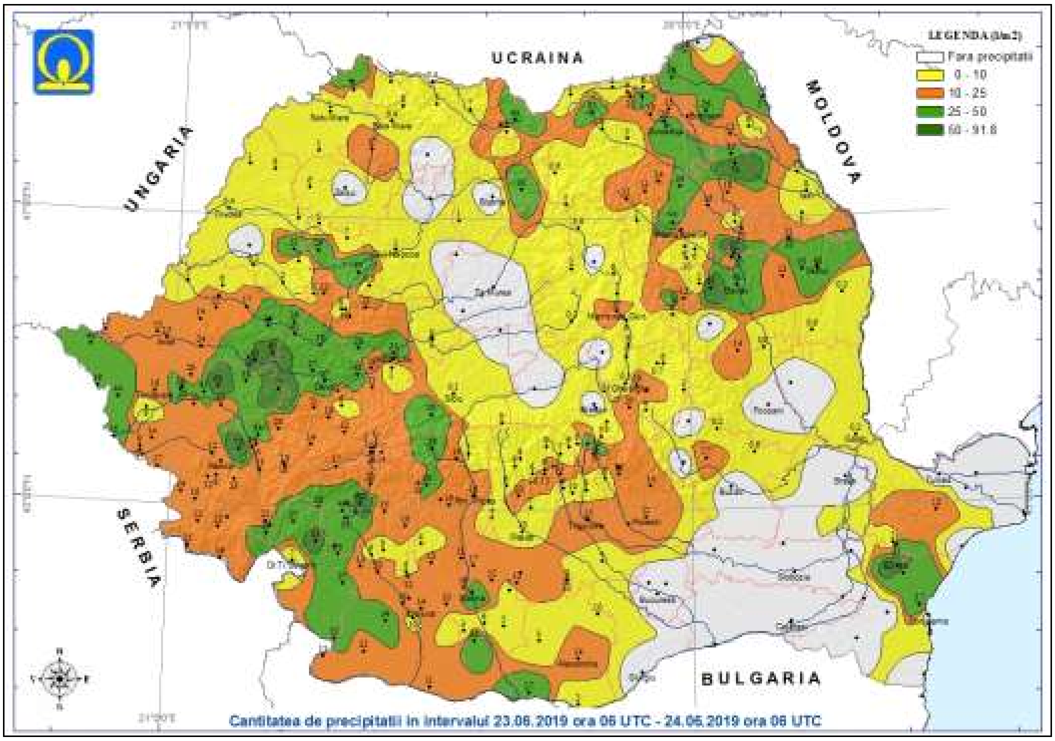

Figure 14 Quantities of water recorded in 24 hours (l/sqm), at the Meteorological Stations of Moldavia region, on June 23, 2019.

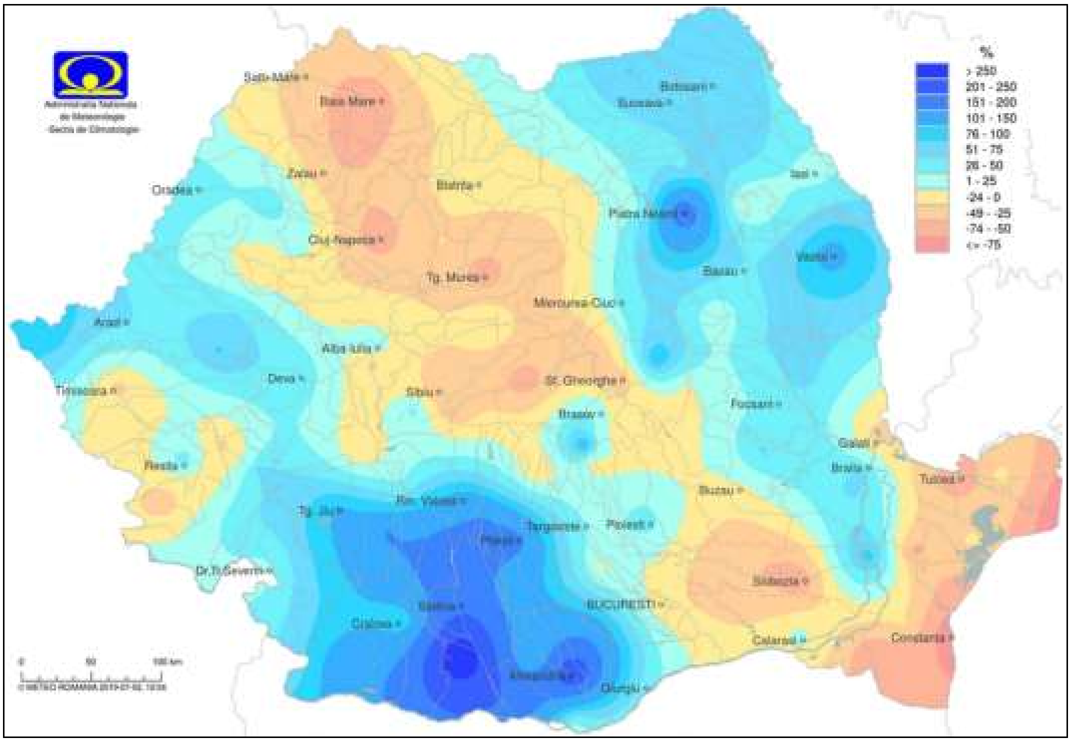

Figure 15 Deviation of the monthly amount of precipitation - June 2019 compared to the multiannual quantities (1981-2010).

In 21 of the days of the month it rained torrentially and the recorded water quantities exceeded by over 100 % the climatological values of the specific precipitations of the month, especially in the counties located in the central part of the region (see Fig. 15) (www.meteoromania.ro).

"Torrential rains are of interest to our country especially in the warm semester of the year, being mainly convective, but can also be generated dynamically, by brutal orographic forcing or by the action of a particularly active cold front (large differences in parameter values of meteorological conditions on both sides of the front, especially in the field of temperature and humidity). […] The climatological norm for precipitation (l/sqm) in Moldova, in June, from 1981-2010, is between 67...103 l / sqm" (Georgescu et al., 2015). In Fig. 14, the distribution of precipitation in 24 hours can be observed. Thus, you can see significant amounts of rainfall in northern and central Moldova, with values between 29.5 and 91.8 l / sqm, with the highest values in Neamț County. The temperature distribution in Moldova indicates that on this day, the maximum temperatures were higher than the climatological norms of the date, which is why the development of convection was facilitated (in close connection with the high relative humidity) on this day. The maximum temperature was between 25.5 degrees Celsius in Rădăuţi and 34.7 degrees Celsius in Galaţi (while the climatological norm of the maximum temperature for this day in Moldova is between 23.8 and 27.9 degrees Celsius).

4. Results and discussion

The forecast of torrential rainfall is quite laborious and sometimes difficult. The difficulty lies in estimating the quantitative threshold and the spatial distribution of rainfall.

The forecasts models from the morning of June 23, at 06 UTC, indicated relatively low signals of the events that could have taken place on that day, with a higher probability on the northern group of the mountainous area (Eastern Carpathians). Due to minor changes in the air circulation in the lower troposphere, the convective phenomena were much more severe than those anticipated by the forecast models.

In such situations, the forecasting activity has a way to solve this problem, through very short-term forecasts, nowcasting type messages. One of the aims of this paper was to present such an example.

Starting with 2006, as for other meteorological phenomena, the degree of danger is expressed by the color codes assigned to the counties. The maps express the intensity of the atmospheric phenomena that generate a dangerous phenomenon, and the texts of the warning messages bring details about the intensity of the phenomenon. Meteo-climatic phenomena are part of natural hazards, which cannot be avoided, but the evolution on the national territory can be anticipated by meteorologists of the National Meteorological Administration, the institution that has all the necessary infrastructure for observation, detection and forecasting of any meteorological phenomenon (Huștiu, 2016).

Thus, on June 23, 2019, 23 immediate warning messages were issued until midnight, regarding torrential rains, storms and hail. From those issued, 21 were orange code warnings and 2 were red code warnings.The phenomena specific to the accentuated instability, manifested especially in the afternoon and evening of June 23, consisted of torrential showers, accompanied by frequent electric discharges, storms (in the county of Bacău, Botoșani and Vaslui) and hail (on Iași, Botoșani, Vaslui and Bacău counties).

The quantities of water falling in short time intervals exceeded 30 l / sqm, on relatively large areas in the north and center of Moldavia region: **Neamț County**: Dămuc - 91.8 l / sqm, Păstrăveni - 40.2 l / sqm, Tg.Neamț - 34.0 l / mp, Dumbrava - 33.5 l / mp, Cuejdi - 33.2 l / mp; **Iași county**: Cotnari - 74.0 l / sqm, Ac. Pîrcovaci - 40.8 l / sqm, S H Cârjoaia - 35.5 l / sqm, Hîrlău - 32.8 l / sqm, **Bacău County**: Valea Budului - 65.0 l / sqm, Măgura - 50.4 l / sqm, Bacău Bârnat - 48.2 l / sqm, Mărgineni - 44.0 l / sqm, Bacău - 42.0 l / sqm, Sulta - 32.4 l / sqm, **Vaslui county**: pp Vaslui - 47.6 l / sqm, pp Negrești - 30.8 l / sqm, pp Oprișița - 30.0 l / sqm, Bumbata - 23.5 l / sqm, pp Dumești - 20.4 l / sqm, **Suceava county**: Suceava - 50.0 l / sqm, Țibeni - 38.1 l / sqm, Lunguleț - 32.5 l / sqm, Gbeste - 20.6 l / sqm, Huțani - 20.0 l / sqm sqm, **Botoșani county**: Pădureni - 38.5 l / sqm, Ștefănești - 37.0 l/sqm, Cristești - 34.0 l / sqm, Leorda - 33.0 l / sqm, Ac.Ezer - 29.5 l / sqm and approached this threshold in the east of the region.

"Everyday life shows us that we do not always know what is the best course of action to be taken in such situations. Therefore, it becomes obvious the need for continuous training measures for the population, in order to acquire a behavior that favors the protection of property, but especially of life becomes obvious. The collective memory of the mature generations in Romania preserves the memory of the floods of the '70 s, considered to be among the most devastating of the twentieth century. Comparable in terms of time and space were the events of 2005, when, as a result of several episodes with heavy rainfall, in spring, summer and autumn, almost all inland river basins were affected, then the Danube as well" (Georgescu et al., 2015). However, we also mention here the floods in Moldova from July 24 and 25, 2008, June 28 to July 3, 2010 and June 11 and 12, 2013, which caused significant material damage and unfortunately human casualties. It is true that for urban areas there are certain vulnerabilities due to insufficiently sized sewers, by water supply from the slopes, by insufficient drainage or by dams and other hydrographic works (Săgeată, 2013), but if the population complied with some basic rules, land damage would be diminished. To avoid land damage, due to torrential rainfall, forests should be more protected and cared for, ditches should be cleaned, garbage should be stored only in specially designed places and not on river banks, houses should not be built in areas at risk of flooding.

In Bacău County, in June 23, 2019, the local press described the severity of the day's events. "The rain and the gusts of wind put the road infrastructure of the county to the test. [...] Following the weather warning messages, orange and red level weather alerts, firefighters were requested to intervene to evacuate water from households in the localities of Valea Budului, Trebeș, Măgura, Hemeiuș" (https://www.desteptarea.ro/).

5. Conclusion

The day of June 23, 2019, from a thermal point of view, did not go out of the pattern that characterized the entire month. The maximum air temperatures were between 26 degrees in Rădăuți (25.5 Celsius degrees) and Suceava (26.4 Celsius degrees) and barely reached the heatwave threshold of 35 degrees (respectively 34.7 Celsius degrees) in Galați. These values, corroborated with the presence of a high percentage of relative humidity, determined an accentuated thermal discomfort in the counties of Iași, Vaslui, Bacău, Vrancea and Galați.

Although the indices of instability and shear indicated by the forecast models were below the usual threshold for generating severe phenomena in the region, the presence of tropical air in conjunction with the lifting of air in the atmosphere between 700 and 500 hPa, generated the severity of the storms in that evening in northern and central Moldavia region. The forecasts models from the morning of June 23, at 06 UTC, indicated relatively low signals of the events that could have taken place on our reference day, with a higher probability on the northern group of the mountainous area (Eastern Carpathians). Subsequent runs, which captured some more intense cores, shifted their position as well as their very low spatial distribution. In reality, large areas of northern and central Moldavia region were affected where the amounts of precipitation fell between 25 and 50 l / sqm.

There are situations when NWP do not anticipate certain severe events in the hot season. However, the interpretation of several NWP (on a synoptic scale or mesoscale), the analysis of meteorological parameters frequently used in operational meteorology, satellite imaging and radar, and the interpretation of maps representing the vertical distribution of isentropes - allowed the correct assessment of severe phenomena in the region of Moldavia, from that day.

Such dangerous phenomena cannot be avoided, but the consequences on the ground could be diminished if the population was aware of the connection between environmental damage and the increased risk of natural disasters.

The meteorological warnings issued in the afternoon and evening of June 23, 2019 informed the authorities in time, the population was alerted by RO ALERT messages and the intervention on the field was done in a timely manner.

References

Bostan, D. C., Pasat, C., Miclăuș, I. M. 2018. Precipitațiile intense din iunie 2018. Inundații în județul Bacău, poster, Sesiunea Anuală de Comunicări Științifice a Administrației Naționale de Meteorologie din 14-16 noiembrie 2018, București.

Administrația Națională de Meteorologie. 2008. Clima României, 2008, Editura Academiei Române, ISBN 978-973-27-1674-8 București.

Georgescu, F., Dima, V., Irimescu, A., Stăncălie, Gh., Roceanu, I., Beligan, D. 2015. Inundațiile-fenomene de risc. instruirea preventivă a populației prin jocuri educative, Editura Printech, București.

Huștiu, M. C. 2016. Clima și hazardele meteo-climatice din Podișul Bârladului, Teză de doctorat, Academia Română, Institutul de Geografie, București.

Maier, N., Bilaşco, Şt., Horváth, C. 2011. Cluj-Napoca precipitation forecast using WSR-98D Doppler Radar, Geographia Napocensis, 2, 97-104.

Runcanu, T. D., V. Bacinschi, Pescaru, I., Makkai, G., Tanczer, T. 2014, Dicționar meteorologic, Ediția a II-a, ISBN 978-973-0-17096-2, sub egida Societății Meteorologice Române, București.

Săgeată, R., Dumitrescu, B., Grigorescu, I., Persu, M. 2013. Tipologii privind vulnerabilitatea la inundaţii a oraşelor din România, Wulfenia, 20(11), 274-290.

Sun, J., Chai, J., Leng, L., Xu, G. 2019. Analysis of lightning and precipitation activities in three severe convective events based on Doppler Radar and Microwave Radiometer over the Central China Region, Atmosphere, 10, 298-315.

Tanislav, D. 2010. Geografia fizică a României- note de curs, Universitatea Valahia din Târgoviște, Facultatea de Științe Umaniste, 63 (1-136).

Wang, P., Gu, K., Hou, J., Dou, B. 2020. An automatic recognition method for airflow field structures of convective systems based on single Doppler Radar data, Atmosphere, 11, 142-160.

*** www.meteoromania.ro (April 2020).

*** https://www.ecmwf.int/ (April 2020).

*** https://ready.arl.noaa.gov/index.php (January, 2021).
*** http://www1.wetter3.de/ (April 2020).
*** http://www.eumetrain.org/ (January 2021).
*** https://www.eumetsat.int/website/home/index.html (January 2021).
*** http://www.estofex.org/ (April 2020).
*** https://www.metoffice.gov.uk/ (April 2020).
*** http://en.blitzortung.org/live_lightning_maps.php (April 2020).
*** https://www.desteptarea.ro/ (June, 2019).
*** https://maps-for-free.com/ (January, 2021).
*** https://www.spc.noaa.gov/ (March, 2021).